# Pneumatic Controller Studies: Past to Present

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# Outline

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  - National data/regional characteristics
  - Previous studies
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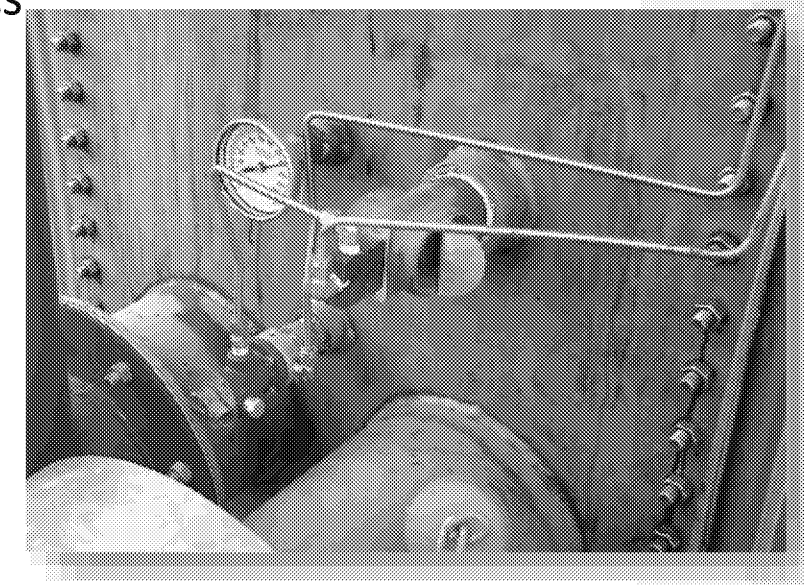
  - Goals
  - Methodology
  - Results
- Denver-Julesburg Basin PC Study
  - Goals – how it is different
  - Methodology
  - Preliminary Results





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# Why are PCs Important

## National Data

- 892,403 PCs in use at natural gas and petroleum production sites
  - 477,606 PCs at natural gas production sites
  - 414,797 PCs at petroleum production sites (2014 GHG Inventory)
- 1st largest methane contributor (GHGRP-W Onshore Production)
- Methane emissions from production field operations have increased by nearly 80 percent since 1990 (2016 GHG Emissions & Sinks)

**Table 3-37: $CH_4$ Emissions from Petroleum Systems (kt)**

| Activity | 1990 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|
| **Production Field Operations (Potential)** | **1,519** | **1,957** | **2,193** | **2,263** | **2,347** | **2,586** | **2,725** |
| Pneumatic controller venting[a] | 761 | 1,209 | 1,328 | 1,346 | 1,332 | 1,509 | 1,567 |
| Tank venting | 250 | 188 | 210 | 220 | 278 | 330 | 396 |
| Combustion & process upsets | 115 | 91 | 98 | 101 | 108 | 114 | 122 |
| Misc. venting & fugitives | 334 | 421 | 502 | 540 | 570 | 573 | 578 |
| Wellhead fugitives | 59 | 48 | 54 | 56 | 59 | 60 | 62 |
| Production Voluntary Reductions | (0) | (36) | (60) | (45) | (45) | (31) | (31) |



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# Why are PCs Important

## National Data

- Activity Data vs Emission Factors
  - Activity factors range from 0.5 to 1.6 pneumatic controllers per well (GRI/EPA 1996)
  - GHG Subpart W Emission factors
    - Low Continuous Bleed PCs = 1.39 scf/hr
    - High Continuous Bleed PCs = 37.3 scf/hr
    - Intermittent Bleed PCs = 13.5 scf/hr

**Table 3-42: $CH_4$ Emissions from Pneumatic Controllers (MMT $CO_2$ Eq.)**

| Source | 1990 | 2005 | 2010 | 2013 | 2014 |
|---|---|---|---|---|---|
| **All** | **19.0** | **30.2** | **33.2** | **37.7** | **39.2** |
| High bleed | 17.8 | 17.5 | 12.6 | 5.5 | 4.7 |
| Low bleed | 1.2 | 1.8 | 2.0 | 1.4 | 1.2 |
| Intermittent bleed | + | 10.9 | 18.6 | 30.9 | 33.3 |
| ***Previous-All*** | ***12.2*** | ***10.1*** | ***10.8*** | ***11.9*** | ***NA*** |
| *Previous-High bleed* | *9.5* | *7.8* | *8.4* | *9.2* | *NA* |
| *Previous-Low bleed* | *2.8* | *2.3* | *2.4* | *2.7* | *NA* |

# Why are PCs Important

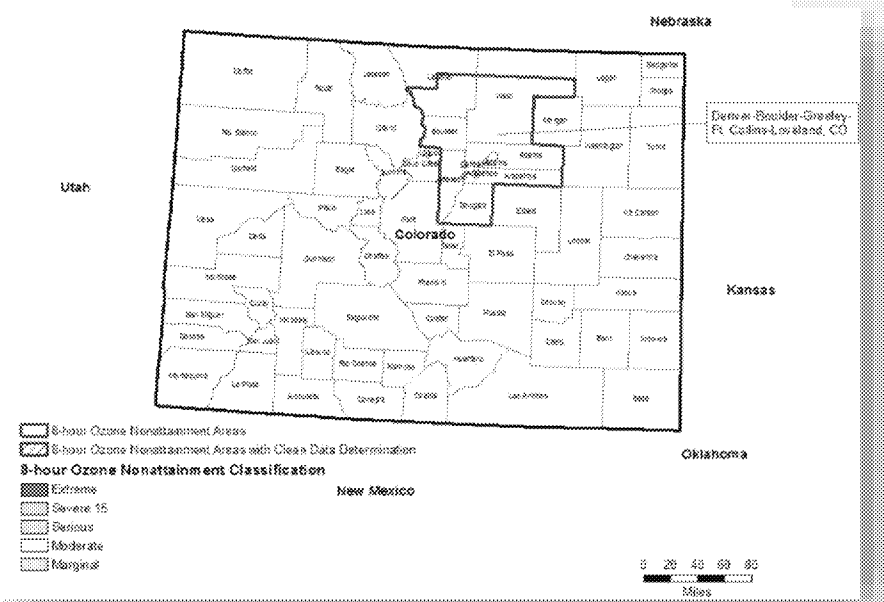
## Federal and State Regulations

- Federal regulation of PCs
  - NSPS OOOO & OOOOa
    - No Bleed requirement at gas processing plants
    - Low-bleed (<6 scf/h) requirements at non-gas processing plants
  - GHGRP Subpart W
    - Reporting threshold: >25,000 metric tons of CO2 equivalent
    - Source categories include pneumatic devices
- State regulation
  - UDAQ pneumatic retrofit rule
    - Requires all existing PCs to meet NSPS OOOO standards
  - CDPHE Reg 7. Section XVIII
    - Requires emission reductions, monitoring and recordkeeping

# Why are PCs Important

## Regional Characteristics

- Differences between “top down” and “bottom up”
- D-J Basin non-attainment status
  - Moderate
- Uinta Basin non-attainment status
  - Marginal (<6250’)



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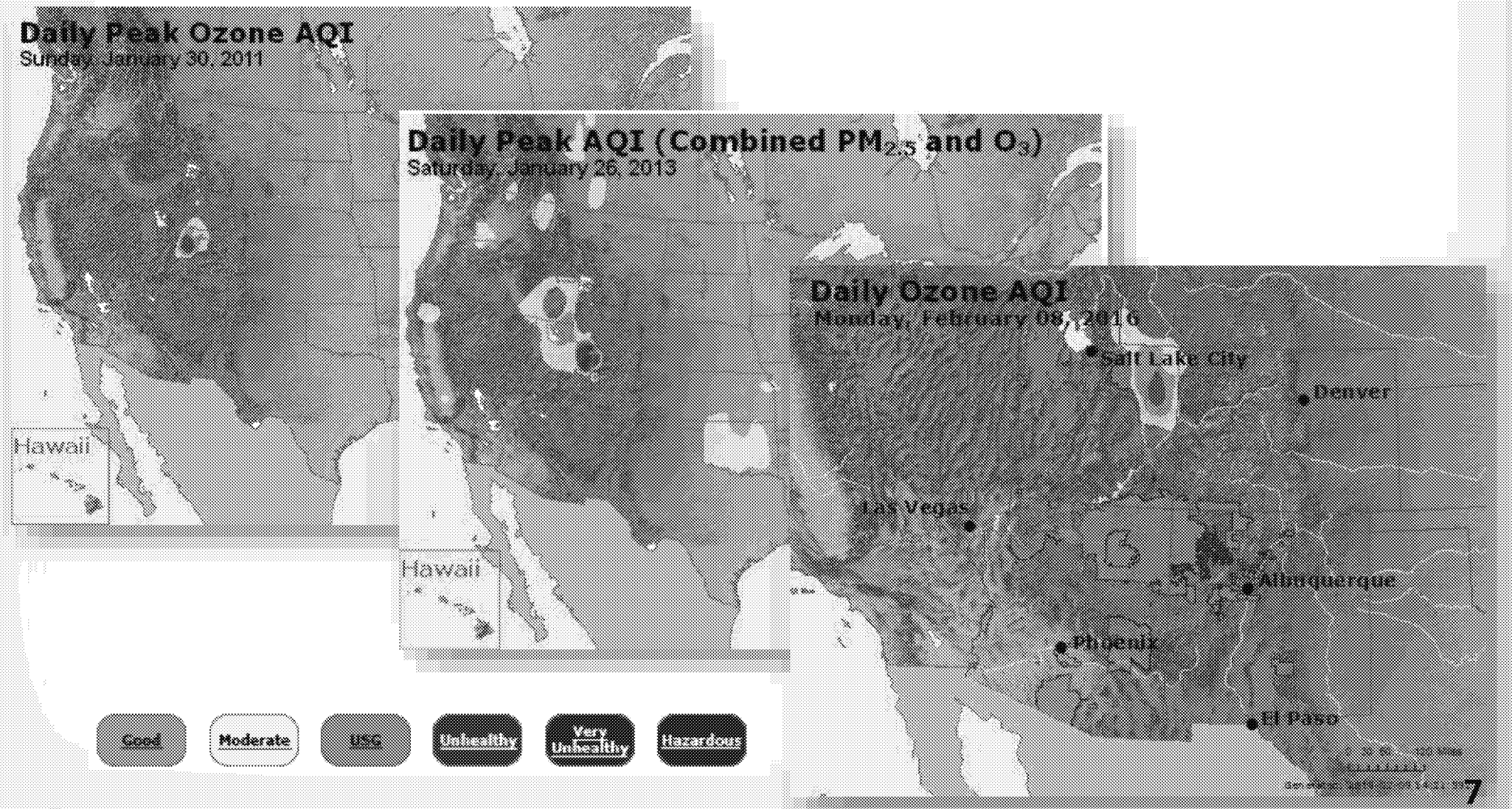
# Why are PCs Important

## Regional Characteristics



# University of Texas/EDF Study (Dave Allen et. al., 2014)

- Focus: Methane emissions from process equipment at production sites
- Pneumatic controller emissions
- Key results related to Pneumatic Controllers:
  - 377 PCs sampled from 65 sites
    - 125 PCs from 7 sites in Rocky Mountain region
  - 5.5 scf/hr whole gas average emission rate (4.9 scf/hr methane)
  - 19% of PCs had emission rates >6 scf/hr and accounted for 95% of all emissions
    - "Small subset of PCs accounts for majority of emissions"

Table 1. Sample Population, Categorized by Controller Application and Region (AP= Appalachian; GC = Gulf Coast; MC = Mid-Continent; RM = Rocky Mountain)

| | | number of controllers sampled, categorized by application | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| region | separator | process heater | compressor | wellhead | plunger lift | dehydration system | flare | sales | total |
| AP | 14 | 13 | 0 | 24 | 1 | 0 | 0 | 0 | 52 |
| GC | 73 | 0 | 13 | 11 | 7 | 17 | 1 | 1 | 123 |
| MC | 48 | 11 | 7 | 0 | 11 | 0 | 0 | 0 | 77 |
| RM | 51 | 21 | 0 | 32 | 11 | 8 | 2 | 0 | 125 |
| total | 186 | 45 | 20 | 67 | 30 | 25 | 3 | 1 | 377 |



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# University of Texas/EDF Study (Dave Allen et. al., 2014)

- Results compared to 2012 GHG NEI
  - Emissions per controller were 17% higher
  - 2.7 PCs/well compared to 1.0 PCs/well
- Regional differences:
  - Rocky mountain region had lowest ER
  - Gulf coast region had the highest ER
  - Potential reasons for regional difference:
    - Actuation frequency
    - Continuous vs intermittent bleed

Table 3. Frequency of Actuations and Emissions from Intermittent Vent Controllers Where Actuations Were Observed, Categorized by Region

| region | count of devices | frequency of actuations (#/min) | avg. emission rate (scf/h) |
|---|---|---|---|
| AP | 8 | 2.42 | 4.85 |
| GC | 30 | 0.37 | 20.5 |
| MC | 17 | 0.93 | 5.05 |
| RM | 25 | 0.43 | 1.72 |
| total | 80 | average: 0.73 | average: 9.76 |

Table 2. Whole Gas Emissions from Controllers (scf/h), Categorized by Region and Application[a]

| | | average whole gas emission rates from controllers (scf/h), categorized by the application | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| region | all devices | separator | process heater | compressor | wellhead | plunger lift | dehydration system | flare | sales | avg. w/o compressors |
| AP | 1.7 | 0.3 | 1.3 | | 2.8 | 0.0 | | | | 1.7 |
| GC | 11.9 | 16.3 | | 10.6 | 0.0 | 7.3 | 4.3 | 0.0 | 0.0 | 12.0 |
| MC | 5.8 | 4.9 | 0.0 | 20.2 | | 6.5 | | | | 4.4 |
| RM | 0.8 | 1.5 | 0.2 | | 0.4 | 0.1 | 0.0 | 0.0 | | 0.8 |
| average | 5.5 | 8.1 | 0.5 | 14.0 | 1.2 | 4.1 | 3.0 | 0.0 | 0.0 | 5.0 |

[a]Numbers of devices sampled in each category are reported in Table 1.



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# Oklahoma Independent Petroleum Association Study (2014)

- Focus: Pneumatic controller emissions from production facilities

**Exhibit 2: Key Observational Results**

**SITES**

172 sites (205 wells) visited for data collection
162 sites (190 wells) had natural gas pneumatic controllers
10 sites (15 wells) did not have natural gas pneumatic controllers

**CONTROLLERS**

680 natural gas pneumatic controllers
77 controller models
659 intermittent vent controllers
21 continuous bleed controllers

**AVERAGE CONTROLLER COUNTS**

4.0 pneumatic controllers per site
5.0 pneumatic controllers per new gas site
3.1 pneumatic controllers per old gas site
3.6 pneumatic controllers per well
5.3 pneumatic controllers per new oil site
2.7pneumatic controllers per old oil site

**ACTUATION FREQUENCIES**

538 controllers (79%) had no actuations detected during the observation period and were assigned the default rate
126 controllers (19%) had actuation rates less frequent than the once per 15 minute default rate
16 controllers (2%) had actuation rates more frequent than or equal to the default rate



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# Oklahoma Independent Petroleum Association Study (2014)

- Focus: Pneumatic controller emissions from production facilities
- 680 PCs surveyed:
  - 659 intermittent bleed PCs (97%)
    - 3.83 PCs/site
    - 0.40 scf/h emission rate
  - 21 continuous bleed PCs (3%)
    - 0.12 PCs/site
    - 21.54 scf/h emission rate
- Study did engineering estimates of emission rates not direct measurements

**Exhibit 4: Average controller emissions**

| | scf/hour | Mscf/year | lb/hour | ton/year |
|---|---|---|---|---|
| All controllers | | | | |
| Gas | 1.05 | 8.78 | | |
| Methane | 0.85 | 7.08 | 0.030 | 0.125 |
| VOC | 0.085 | 0.70 | 0.012 | 0.049 |
| Intermittent Vent | | | | |
| Gas | 0.40 | 3.24 | | |
| Methane | 0.33 | 2.64 | 0.012 | 0.047 |
| VOC | 0.031 | 0.25 | 0.004 | 0.018 |
| Continuous Bleed | | | | |
| Gas | 21.54 | 182.65 | | |
| Methane | 17.23 | 146.15 | 0.609 | 2.585 |
| VOC | 1.79 | 15.05 | 0.247 | 1.038 |

- Actuations:
  - 142 of 680 (21%) PCs actuated during 15 min observation
  - Only 2% had actuations > once per 15 minutes
  - 79% had no actuations observed during sampling
  - 269 of 680 (40%) were backpressure controllers used for overpressure protection and rarely actuate

# Parsino Study (2013)

- Focus: determining bleed rates for pneumatic devices
- Location: British Columbia (28 fields) and Alberta (2 fields)
- Key takeaways:
  - 581 PC surveyed from 8 operators
    - 254 Level, 43 Position, 142 Pressure, 41 Temperature and 101 Transducer
  - Direct measurements with flow meters for 30 minute sample periods
    - Measured high-bleed controllers (i.e. >6 scf/hr)
  - Determined bleed rates:
    - Specific PC model bleed rate (i.e. Fisher 4660, Norriseal 1001, etc.)
    - Generic bleed rate

| Pneumatic Device | Number of Samples | Average Bleed Rate ($m^3$/hr) | 95% Confidence Interval ($m^3$/hr) | Standard Deviation ($m^3$/hr) | P-Value |
|---|---|---|---|---|---|
| High Bleed Controllers | 406 | 0.2605 | 0.2880 | 0.3371 | 0.129 |
| High Bleed Intermittent | 195 | 0.2476 | .2893 | 0.3537 | 0.738 |



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# Missing Data Gaps

- Representativeness
- Measurements
- Limited scope in rocky mountain production basins
- Addressing malfunctions



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# Uinta Basin PC Study

- Goal: improve information on oil and natural gas well pad pneumatic controllers (PCs) and emission measurement methods
  - Increase PC emission measurements in Uinta Basin
  - Forward discussion on what is and what is not a PC emission
  - Improve Uinta Basin activity counts (#PC/well, by function, type …)
  - Improve information on intermittent actuation frequency
  - Improve site-specific gas composition knowledge
  - Understand PC malfunction frequency and repair factors



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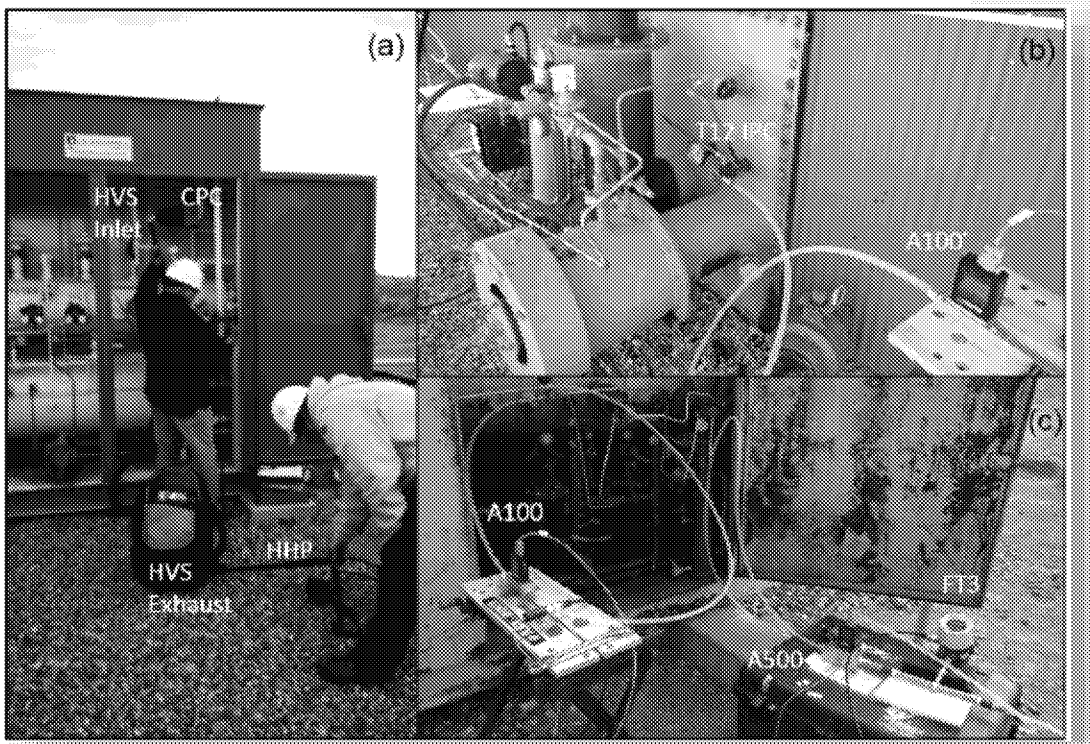
# Uinta Basin PC Study

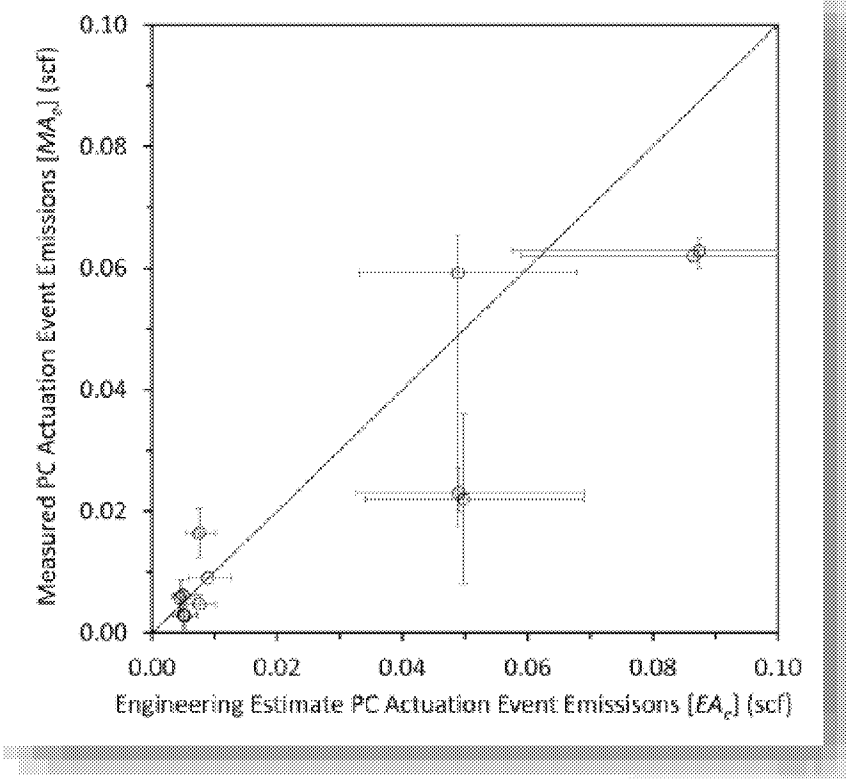
## Study Methodology:

1. Information gathering
2. Emissions screening
   - Hand held probe
   - IR camera
3. HVS emission measurements
4. Mass flow meter measurements
5. Engineering emission estimates



## Study Results: By The Numbers

- 8 facilities
- 80 PCs surveyed
- 96% of the PCs surveyed were intermittent vent type
- 0.36 scf/h whole gas emission rate
  - 1.1 scf/hr CPC emission rate
  - 0.32 scf/hr IPC emission rate
- 10.3 PC systems per well (oil sites)
- 1.5 PC systems per well (gas sites)
- 11 (14%) malfunctioning IPC systems
  - 1.6 scf/h average



# Study Results: By The Numbers

Table 2. PC type summary by site with intermittent vent (IPCs) accounting for 96% of the total.

| Site | PCs | IPCs | PCs per Well | Three Most Common PC Types by Site |
|---|---|---|---|---|
| | (N) | (N) | (N) | Manufacturer, Model Family, (N) |
| Oil 1 | 15 | 15 | 15 | WellMark 7400 (7), Kimray T12 (4), Kimray BP (3) |
| Oil 2 | 14 | 14 | 7 | Kimray T12 (5), Wellmark 7400 (4), Kimray BP (2) |
| Oil 3 | 10 | 10 | 10 | WellMark 7400 (5), Kimray T12 (4), Kimray BP (1) |
| Oil 4 | 12 | 12 | 12 | WellMark 7400 (6), Kimray T12 (5), Kimray BP (1) |
| Oil 5 | 11 | 11 | 11 | WellMark 7400 (6), Kimray T12 (3), Kimray BP (1) |
| Gas 1 | 6 | 5 | 1.3 | WellMark 6900 (3), Kimray T12 (2), Fisher 4460 (1) |
| Gas 2 | 7 | 6 | 2.3 | Kimray T12 (3), WellMark 6900 (2), Fisher 4460 (1) |
| Gas 3 | 5 | 4 | 1.0 | WellMark 6900 (2), Kimray T12 (2), Fisher 4460 (1) |



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# Study Results: By The Numbers

Table 3. Summary PC emission assessment surveys with focus on malfunctions.

| Site | HHP Detects | OGI Detects | Malf. PCs | Malf. PCs | Malf. PC[1] Emission rate(s) |
|---|---|---|---|---|---|
| | (N, %) | (N, %) | (N, %) | Identity | (scf/h) |
| Oil 1 | 0, 0 | 0, 0 | 0, 0 | N/A | N/A |
| Oil 2 | 4, 28 | 1, 7 | 1, 7 | WellMark 7400 (actuator) | 0.7 |
| Oil 3 | 2, 20 | 2, 20 | 2, 20 | Kimray T12 (2) | 1.4, 3.4 |
| Oil 4 | 1, 8 | 0, 0 | 0, 0 | N/A | N/A |
| Oil 5 | 6, 55 | 3, 27 | 3, 27 | Kimray T12, WellMark 7400, WellMark 7400 (actuator) | 3.1*^, 0.3, 1.2 |
| Gas 1 | 1, 17 | 1, 17 | 0, 0 | N/A | N/A |
| Gas 2 | 4, 57 | 4, 57 | 2, 29 | Kimray T12, WellMark 6900 | 0.4, 1.6* |
| Gas 3 | 5, 100 | 3, 60 | 3, 60 | Kimray T12, WellMark 6900 (2) | 0.3, 4.5*, 0.6 |

[1]Defined as malfunctioning (malf.) if continuous emissions >0.2 scf/h for IPCs or >6 scf/hr for CPCs [assumes a low bleed category for CPCs (9)]. All measurements were HVS, except (*) by Alicat MFMs. Emission rates are whole gas at standard conditions with gas stream composition correction factors applied. (^) Multiple PC systems with hidden tubing, location of emission not identified, 3.1 scf/h arbitrarily assigned to Kimray T12.

## Study Results: Discussion

- Average IPC emission rate estimate of 0.32 scf/h is significantly lower than the GHG Inventory IPC emission factor of 13.5 scf/h
- Emissions were dominated by malfunctioning PC systems
- Measurement of continuous emissions from malfunctioning IPCs are critical for understanding the population
- Malfunction rate was found to be 14% with these PC systems emitting at levels four times the study average
- Limited scope and nonrandomized sampling

Results published in Journal of Environmental Protection, 2017, 8, 394-415



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# Denver-Julesburg Basin PC Study

- Goal: improve information on oil and natural gas well pad pneumatic controllers (PCs) including malfunction frequency and emission rates
  - Utilize a subset of methods from the Uinta Basin study to focus on less-invasive procedures and so will allow more measurements and more sites to be visited
  - Improve D-J Basin activity counts (#PC/well, by function, type …)
  - Improve methods to characterize PC emissions
  - Increase CPC emission measurements in Denver-Julesburg Basin
  - Forward discussion on what is and what is not a PC emission
  - Understand PC malfunctions: frequency and emission rates



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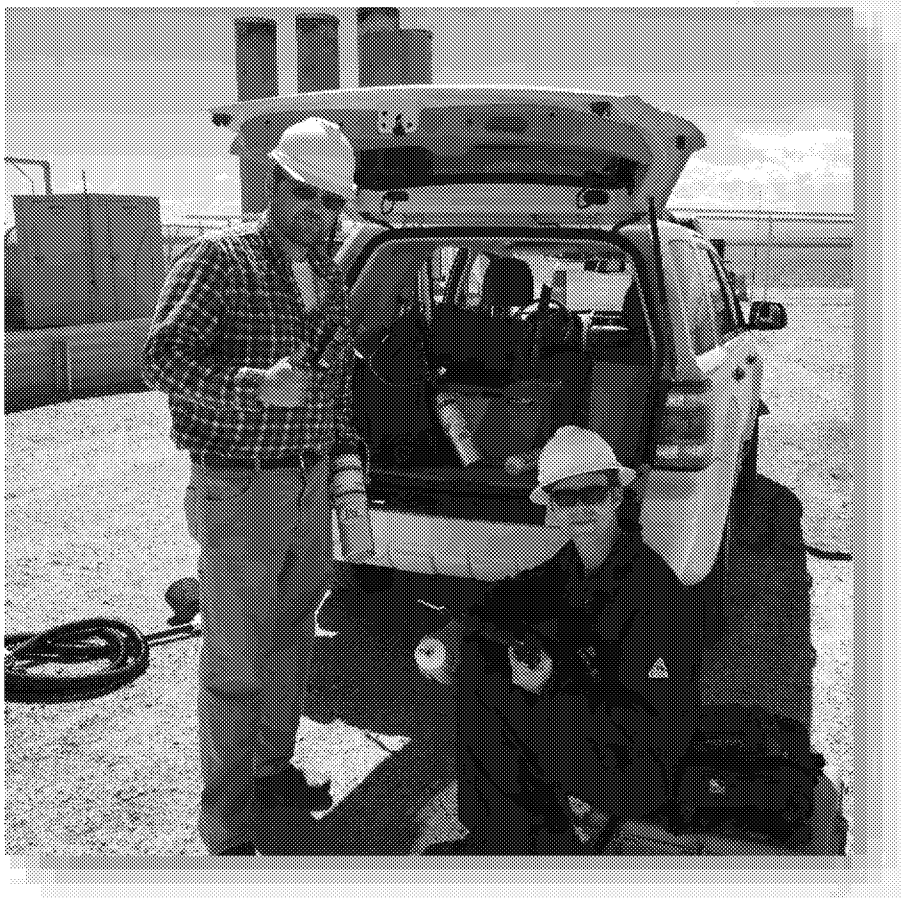
# Denver-Julesburg Basin PC Study

## Study Methodology:

1. Information gathering
2. Emissions screening
   - IR camera
3. CPC emission measurements





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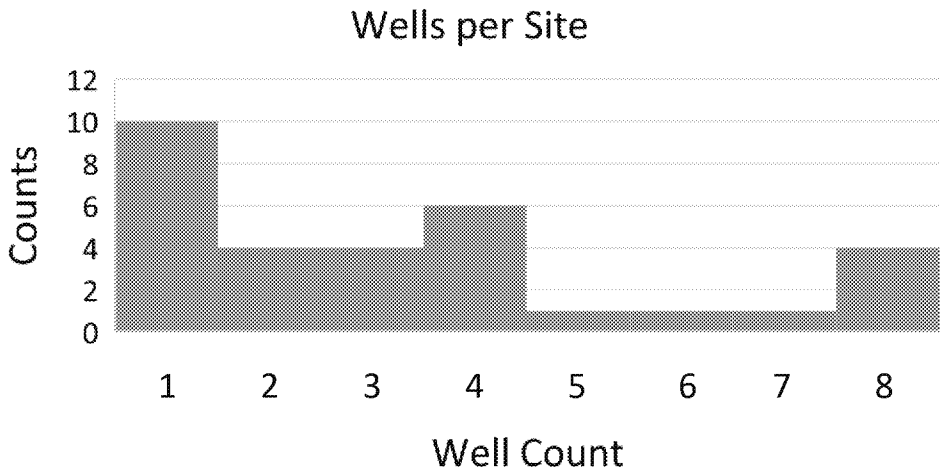
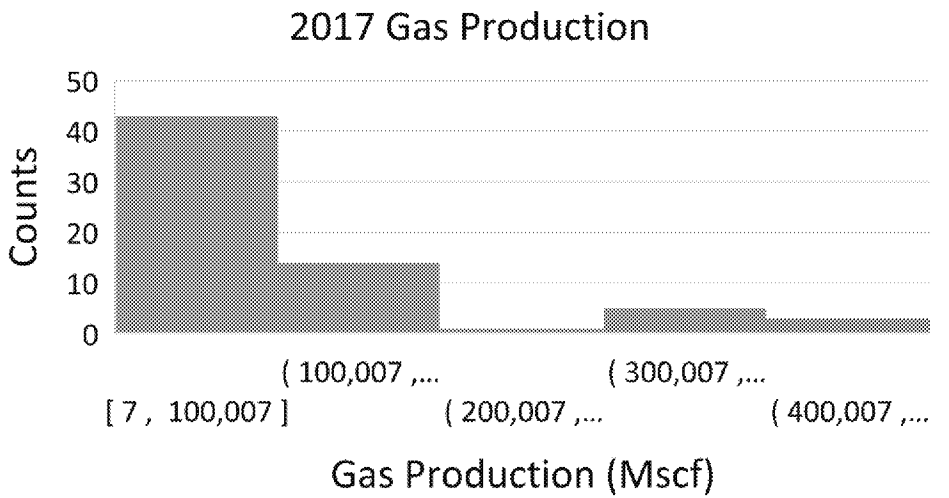
# Denver-Julesburg Basin PC Study

## Study Preliminary Results:

- 31 facilities
  - Spud Dates: 4/23/1976 to 7/26/2015
- 7 operators
- 640 PCs surveyed
- 6.27 PCs per Well
- PC type
  - 76.09% Pilot-Actuator
  - 23.91% Integrated
- Depressurization
  - 87.50% IPC
  - 12.50% CPC
- Motive Gas
  - 94.06% Natural Gas
  - 5.94% Instrument Air



# Denver-Julesburg Basin PC Study

## Study Preliminary Results:

### IR Camera Survey

- 27 Actuations observed
- Auto Mode emissions: 10.00%
- HSM emissions: 20.31%
- Continuous emissions: 13.73%

### HVS Measurements

- 17 PCs measured
- 70% of measurements had steady continuous emission rate
- Emission rates
  - Highest emission rate: 53.0 cf/hr
  - Average emission rate: 4.788 cf/hr



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